Early results of the ESO VLT

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Abstract. The results of the FORS and ISAAC Science Verification of the FORS and ISAAC instruments at the VLT ANTU/UT1 are described. The following observations have been carried out: 1) the Cluster Deep Field MS1008.1-1224 2) the Antlia dwarf spheroidal Galaxy 3) multiple Object Spectroscopy of Lyman break galaxies in the AXAF and Hubble Deep Field South 4) ISAAC IR Spectroscopy of a gravitationally magnified galaxy at z=2.72. The data have been made public for the ESO community and, in the case of HDF-S, worldwide.

1. Introduction

The general goals that ESO intended to reach with Science Verification (SV) Observations were manifold (Giacconi et al. 1999): *i)* to experiment with scientific observing runs, including the end-to-end VLT dataflow (Silva and Quinn, 1997), *ii)* to produce data of scientific quality, involving as early as possible the ESO community in their analysis, *iii)* to foster an early scientific return from the VLT, *iv)* to obtain feedback about the telescope performances and operational procedures.

To this end an SV team has been formed at ESO, under the leadership of A.Renzini. A first block of SV observations has been carried out in August 1998 with the VLT test camera. Results have been published in Vol. 343 of the A&A Journal. A second block of SV observations was planned to be executed in January and February 1999 and in particular with the two instruments for optical/IR imaging and spectroscopy: FORS1 (Nicklas et al. 1997) and ISAAC (Moorwood 1997). The FORS-1/ISAAC SV Team includes the following scientists: J. Alves, S. Cristiani, R. Hook, R. Ibata, M. Kissler-Patig, P. Møller, M. Nonino, B. Pirenne, R. Rengelink, A, Renzini, P. Rosati, D. Silva, E. Tolstoy, and A. Wicenec. The actual schedule of the SV observations was more complex than originally planned and benefitted from observations executed by the FORS1 and ISAAC Commissioning Teams.

FORS1 and ISAAC are rather complex instruments, with many observing modes. The goal of the SV has been to cover the main modes, selecting scientific programmes of outstanding interest. The following observations are briefly described here:

1. The Cluster Deep Field MS1008.1-1224
2. The Antlia dwarf spheroidal Galaxy

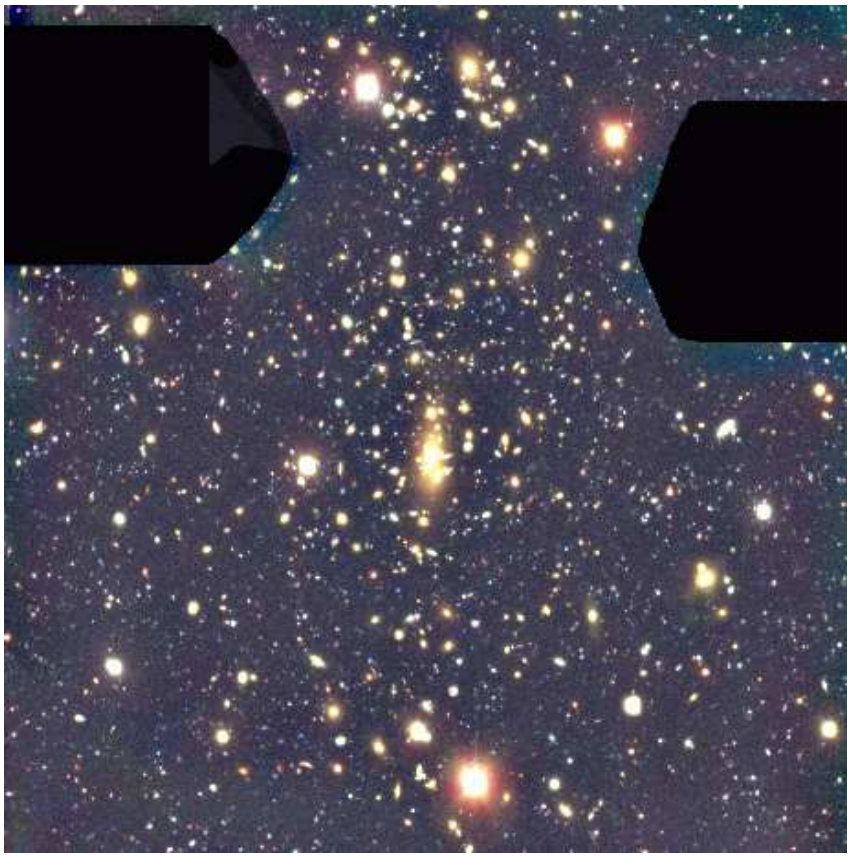

Figure 1. Combined color image of the Cluster MS1008.1-1224

3. Multiple Object Spectroscopy (MOS) of Lyman break galaxies in the AXAF and Hubble Deep Field South

4. ISAAC IR Spectroscopy of the gravitationally magnified galaxy at z=2.72 MS1512cB58.

2. The FORS-ISAAC Cluster Deep Field MS1008.1-1224

The criteria inspiring the selection of the cluster were: existence of published data indicating a large mass/velocity dispersion at redshift$=0.3-0.5$, existence of gravitational arcs, optimal visibility throughout most of the night in January-March (i.e. RA=8-11hr). The selection narrowed on the X-ray selected cluster MS1008.1-1224 (RA = 10 10 32.2, DEC =–12 39 55. ep.2000) from the Einstein Medium Sensitivity Survey (EMSS, Gioia and Luppino, 1994) at z=0.30, also part of the CNOC Survey (Carlberg et al. 1996).

BVRIJK observations were carried out with total integration times between 4000 and 5400 s in the optical and about 1h in the IR. The K-band observations were obtained under exceptional seeing conditions and produced de-jittered coadded images of $0.4''$ PSF.

These data will be used for: *a)* a detailed study of the cluster mass distribution from gravitational lensing shear maps, magnification bias and strong lensing features, *b)* a study of the cluster galaxy population down to ~ 4 mag below

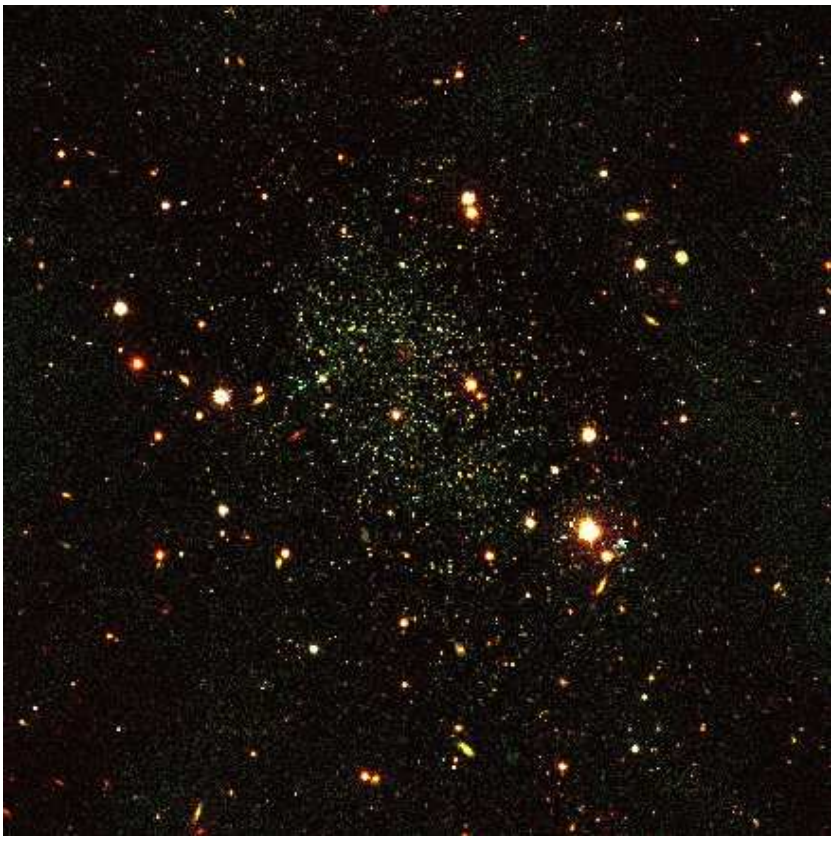

Figure 2. Combined color image of the Dwarf Galaxy Antlia

L*, using color-mag diagrams, *c)* a search for highly magnified distant galaxies, *d)* obtaining photometric redshifts of all galaxies in the field, *e)* identifying interesting stars in the field.

3. The Antlia Dwarf Spheroidal Galaxy

Antlia is a small low surface brightness dwarf spheroidal type galaxy (RA= 10 04 04, DEC=–27 19 49, ep. 2000, l=263, b=22) first noted in an HI survey of southern hemisphere galaxies by Fouqué et al. (1990), which was discovered in 1997 to be an outlying member of the Local Group. This galaxy was selected for the SV because: published data indicate a distance close enough to allow the detection of resolved stars well down the Red Giant Branch, there is a controversy about the existence and importance of a young stellar population and reddening in Antlia and the visibility is optimal in January-March.

Images have been obtained with FORS in B ($4 \times 600s$), V ($4 \times 600s$) and I ($18 \times 300s$), all with a PSF close to $0.5''$. The combined color image is shown in Fig. 2.

These data will be used for: *i)* a detailed study of the Colour-Magnitude diagrams to determine the properties of the resolved stellar population in this small nearby, relatively isolated galaxy, *ii)* determining if there is a young population from the presence or absence of a Main Sequence, *iii)* comparing the properties of a more distant dwarf spheroidal galaxy with those we see around

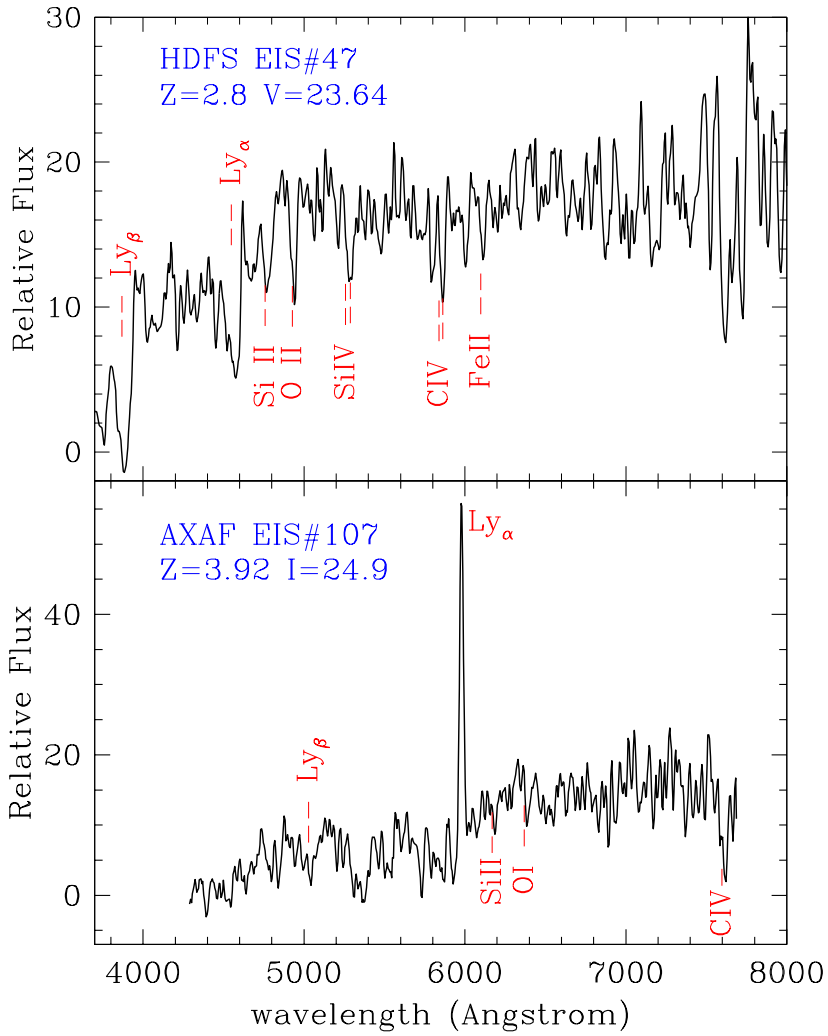

Figure 3. Spectra of two high-z galaxies in the AXAF and Hubble Deep Field South

our Galaxy, *iv)* a study of the reddening properties of this system with colour-colour diagrams, *v)* confirming the distance to this system.

4. Multiple Object Spectroscopy of Lyman break galaxies in the AXAF and Hubble Deep Field South

The study of Lyman-break galaxies was the main spectroscopic programme of the FORS1 Science Verification. The science goals are: *i)* to push the FORS1 MOS to the limits and optimize its observational strategy and data reduction procedures for the specific case of faint galaxies, *ii)* to provide pilot observations for future studies aiming at characterizing the abundance of high-redshift galaxies by luminosity, size, morphology, star formation rate and clustering, *iii)* to check and refine the photometric selection criteria for high-z galaxies, *iv)* help

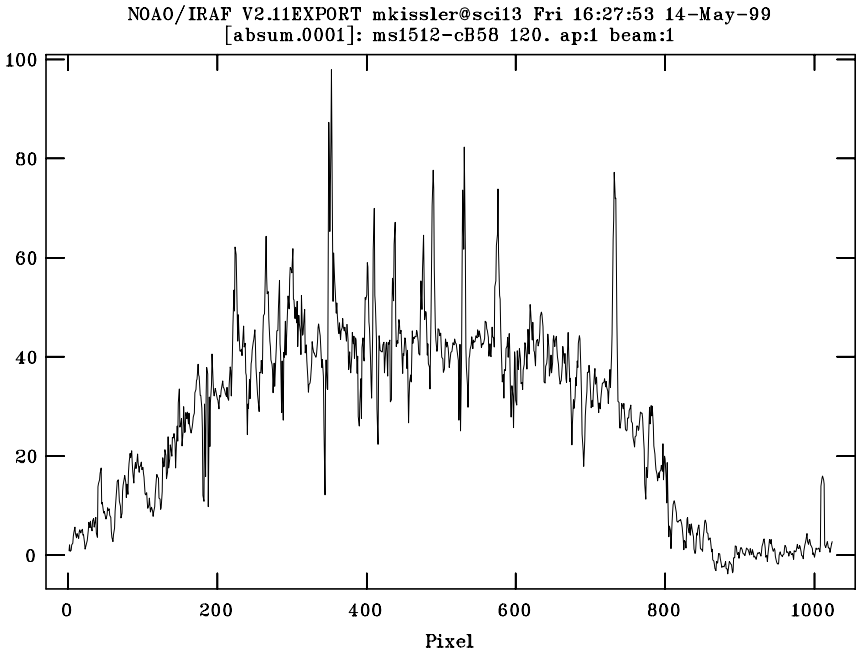

Figure 4. Uncalibrated ISAAC spectrum of the galaxy MS1512-cB58

to tune future wide-angle optical surveys to maximize the yield of Lyman-break galaxies, *v)* to provide galaxies in suitable redshift ranges for future spectroscopic observations with ISAAC.

The AXAF field (Giacconi et al., 1998) was selected for SV observations, given the availability of deep multi-color imaging obtained with SUSI-2 and SOFI and derived catalogues produced by the EIS project. Data of the same type were also publicly available for a field including the WFPC-2 pointing in the Hubble Deep Field South. Targets in this latter field were provided to the FORS1 commissioning team and were observed by them in December 1998. Targets were extracted from the lists of U and B dropouts given in Table 5 and Table 6 of Rengelink, R. et al. (1998) for the AXAF field and in Table 9 of da Costa, L. et al. (1998) for the HDF-S. When no suitable candidate was available for the allowed range of positions of a given slit, a random object in the field was chosen. Spectra of the objects in both the AXAF field and HDF-S have been reduced and analyzed in the same way within the MIDAS package. A total of 8 galaxies with redshifts between 2.8 and 4 were identified. The spectra of two of them are shown in Fig. 3. A full table and details of the reduction are given at the URL `http://http.hq.eso.org/science/ut1sv/MOS_index.html`.

5. Low-resolution spectroscopy in the H band of MS1512-cB58

The gravitationally lensed galaxy MS1512-cB58 was serendipitously discovered by Yee et al. (1996), in the course of the CNOC cluster survey. It lies in the field of the z=0.36 cluster MS1512+36, and its redshift was derived from a dozen strong absorption lines in the rest frame UV (Ellingson et al. 1996). Most interestingly, this galaxy is gravitationally amplified by a factor of about

30. Its near-IR magnitudes are J=19.12, H=18.42, K'=17.83, i.e. the object has exceptionally bright apparent magnitudes for its redshift. Therefore, it offers a unique opportunity to get a high S/N infrared spectrum of a high redshift galaxy, with important lines such as H_α (at the edge of the K band) and H_γ (within the H band) being uncontaminated by atmospheric emission/absorption. The detection of such lines would allow a more reliable determination of the star formation rates, compared to other indicators such as [O II] and the UV continuum. More importantly, the profile of such lines - if present - may provide hints on the mass of this high-redshift galaxy. ISAAC is the first instrument that offers this opportunity, and the unusually large amplification factor made it an attractive target for the VLT, in spite of the large zenithal distance at which it can be observed from Paranal. The data were obtained in the night of March 24, 1999. ISAAC was operated in the short-wavelength, low-resolution mode. The SH filter was used (covering 1.4 to 1.82 micron), with the $1''$ slit. The resolution in this configuration is around 500. The pixel scale is $0.147''$/pixel. A preliminary data reduction was carried out with a final exposure of 5040 sec effective exposure time. The result is shown in Fig. 4.

6. Data Access

The data have been made public for the ESO community and, in the case of HDF-S, worldwide. Full details and data request forms can be found at the URL: `http://http.hq.eso.org/science/ut1sv/`.

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